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AIR REFUELING DIRECTOR LIGHTS TRAINER:

ANALYSIS AND EVALUATION OF TRAINING EFFECTIVENESS

By

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FLYING TRAINING DIVISION
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January 1979
Interim Report for Period March 1978 – May 1978

LABORATORY

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

NOTICE

This interim report was submitted by Flying Training Division, Air Force Human Resources Laboratory, Williams Air Force Base, Arizona 85224, under project 1123 with HQ Air Force Human Resources Laboratory, Brooks Air Force Base, Texas 78235.

This technical report has been reviewed and is approved for publication.

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The objectives of this study were to (a) determine whether the pilot students could meet the Criterion Referenced Objectives, (b) evaluate the relative contribution of director lights training to pilot performance, and (c) analyze the configuration of the trainer as a prototype for subsequent models. These objectives were accomplished with 21 pilot students in the Air Refueling (AR) Phase of F-4C training at Luke AFB, Arizona. All pilots received normal syllabus training prior to the AR Phase. A Control Group (n = 10) continued with normal syllabus training, while the Experimental Group (n = 11) received a 1 hour block of training on the Air Refueling Director Lights Trainer. Both groups of students then flew six air refueling missions in the aircraft; four were day and two were night missions. Analysis of the results indicated that the trainer did contribute to learning, hence

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performance, in the aircraft. It was also found that the pilot students continued to improve throughout all missions in the AR Phase.

PREFACE

This effort was conducted by the Flying Training Division of the Air Force Human Resources Laboratory, Williams Air Force Base, Arizona. The research was performed by the Tactical Research Branch at Luke AFB, Arizona. The study was completed under project 1123, United States Air Force Flying Training Development; task 112312, Tactical Combat Aircrew Research and Development; and Work Unit 11231204, Instructional Methods and Media. Mr. William Hopkins and Ms. Sally Rudolph assisted with data analysis. The authors would like to thank the personnel of the 311th Tactical Fighter Training Squadron for participating in the study as instructors and students. Special thanks are extended to Major Robert Hoh (4444th Operations Squadron) for his support for the duration of the study. This technical report covers research performed between March and May 1978.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

List of Illustrations (*Continued*)

LIST OF TABLES

AIR REFUELING DIRECTOR LIGHTS TRAINER: ANALYSIS AND EVALUATION OF TRAINING EFFECTIVENESS

I. INTRODUCTION

An inflight refueling capability is provided on various aircraft to extend their operational range or endurance. In order to assist the receiver pilot in maintaining a correct position during air refueling, receiver director lights are provided as a primary visual reference on the underside of the fuselage of the tanker. This study is the first of two validation studies to be conducted on the Air Refueling Director Lights Trainer. The second study is to be conducted operationally on the E-3A by the 966th Airborne Warning and Control Training Squadron, Tinker AFB, Oklahoma. The time sequence hinges on a similar trainer being built and shipped to Tinker AFB. Work on the duplicate trainer began during April 1978 with a projected delivery date in late June 1978.

Problem Statement and Study Rationale

According to the F-4 Phase Manual (see Appendix A), the director lights on the tanker are to be used as the primary reference during air refueling. On the KC-135 tanker, the lights are located between the nose landing gear and the main landing gear and consist of two rows—the left row for elevation corrections and the right row for fore and aft corrections. Figure 1 depicts the arrangement and colors of the director lights. Note the double bars on the center of each panel, commonly referred to as Captains Bars. The lights are controlled manually by the boom operator in the tanker prior to contact with the receiver. After contact, the boom position automatically illuminates the lights, directing the receiver to the center of the boom envelope. This position is attained when both sets of Captains Bars are illuminated.

It should be noted that the lights do not give true horizontal and vertical information. Angular boom movements cause changes in the up-and-down row of lights, and telescoping movements of the boom cause changes in the fore-and-aft lights (T.O. 1-1C-1-8). Since the axis of the director lights is inclined at a 30-degree angle to the tanker fuselage, both rows of lights interact when the receiver makes a true horizontal or vertical movement. For example, if a true vertical (down) movement was made, the boom would extend and increase its angle with the tanker, giving a combined light indication to "go up and aft." Therefore, pilots encountering the director lights system must understand the interaction of the lights and the necessary control inputs in order to use the system advantageously in maintaining proper position.

There is an inherent problem in the director lights system when a fighter aircraft is air refueling, because the lights were originally designed for use by bombers. Any pilot must first determine what the lights are directing him to do, and then he must make the appropriate response. The difficulty with fighters is that the response for an up-down correction (left row of lights) is primarily made with the control stick which is operated with the receiver pilot's right hand. The same cross-reference is true for the throttle (left hand) and the fore-aft lights (right row). When a pilot in the cockpit of an F-4C refuels, he finds the receiver director lights difficult to see. They are very far forward on the tanker, and with sunlight hitting them, they may be obscured from view. The pilot's seat position and visual angle make a significant difference in the utility of the lights. For example, during this study several pilots mentioned the fact that looking under the canopy bow restricted their field of view to the belly of the tanker.

Study Objectives

The purposes of this study were as follows:

1. Determine whether the pilot students could meet the criterion-referenced objectives (CROs) developed specifically for this study by the 4444th Operations Squadron (Operational Training Development) at Luke AFB using the Air Refueling Director Lights Trainer (see Appendix B).

2. Evaluate the relative contribution of director lights training to pilot performance.

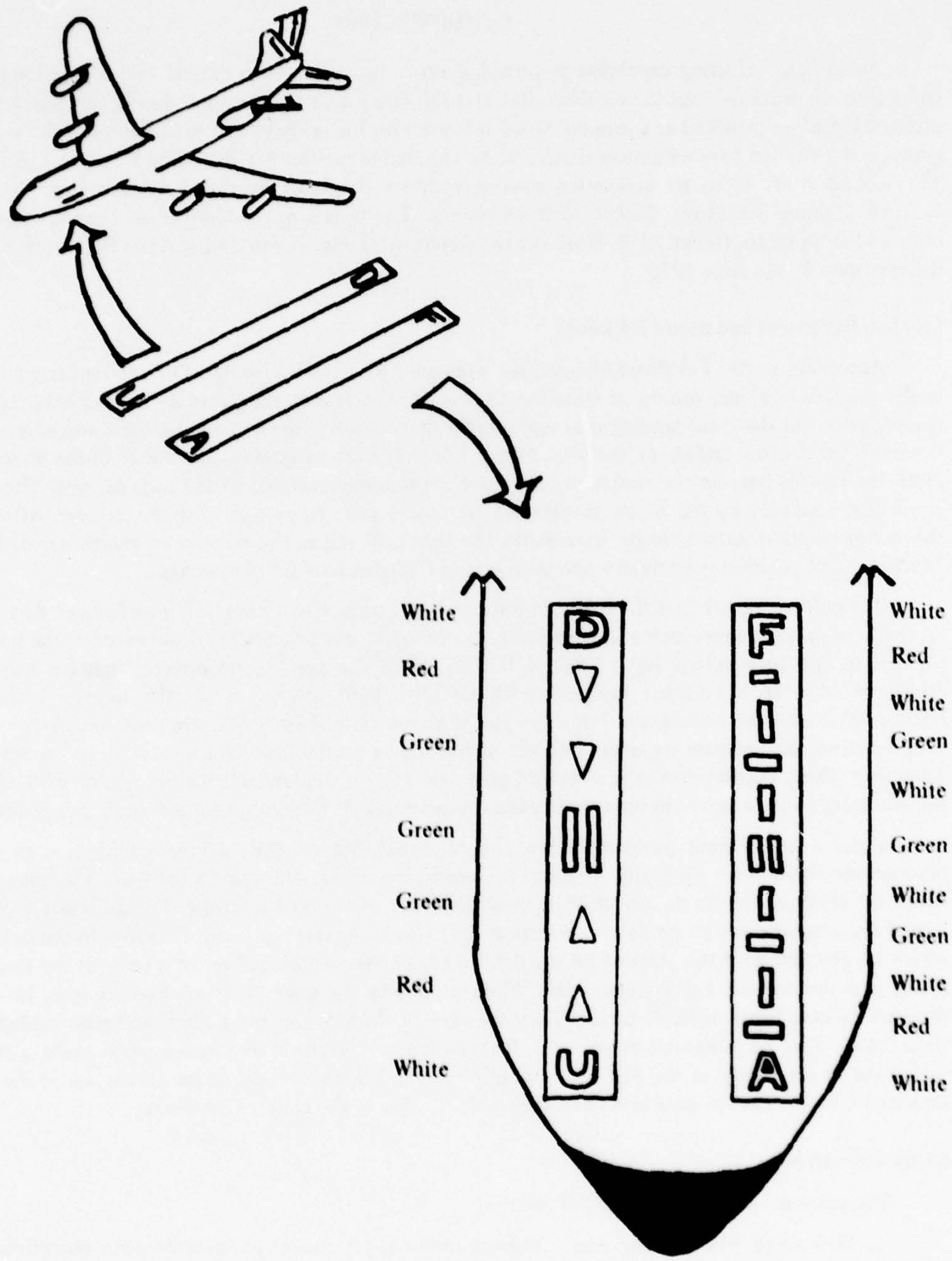

Figure 1. **KC-135 director lights.**

3. Analyze the configuration of the trainer as a prototype for subsequent models.

Background

The impetus for the development of this trainer was an air refueling accident in August 1976 at Luke AFB and a Training Aid Request dated 13 October 1976 sent to the Tactical Air Command/Instructional Systems Division (TAC/DOXS) requesting a trainer be built. The trainer was to be based on a Director Lights Trainer at the 93rd Bomb Wing, Castle AFB, California (see Figure 2). TAC/DOXS in turn directed that it be processed by the Training Aids Group at Luke AFB. In addition, the request specified an analysis be conducted to determine the learning objectives for this device. This analysis was to answer the following questions:

1. Can the training be accomplished with a more economical medium than this device?
2. Is the training equality currently available with other media (i.e. flight simulator)?
3. What functions must this device teach?

Because of the training aspects involved in answering these questions, Training Aids worked closely with the F-4 Operations Training Development (OTD) team to validate the device.

The first model of the trainer (Phase I model) was developed with two small models of the F-4 aircraft attached to the end of booms which were moved in response to the director lights (see Figure 3). These aircraft models had hand grips underneath them for the pilot students to move the aircraft in response to the director lights. An OTD team from 4444th Operations Squadron tested the trainer at the 426th Tactical Fighter Training Squadron (TFTS) at Luke AFB with instructor pilots (IPs), and the results were negative. The psychomotor responses required by the pilots were not realistic and probably would not result in transfer of learning to the aircraft. The IPs indicated that the trainer, in that configuration, would cause negative training effects for the pilot students. Therefore, Training Aids redesigned the trainer into the hardware configuration used for this study. In March 1978, the 4444th Operations Squadron requested assistance in an evaluation of this trainer from the Tactical Research Branch of the Air Force Human Resources Laboratory/Flying Training Division (AFHRL/FT).

II. METHOD

The research design, including objectives and approach, was developed specifically as a candidate training program incorporating the functions the device would teach.

Preliminary Evaluation

A preliminary evaluation of the Director Lights Trainer was accomplished utilizing expert opinions of several IPs from the 311th and 426th TFTS. This preliminary evaluation was to insure that the hardware configuration was adequate to meet the instructional objectives. The responses from the IPs indicated that the trainer design was functionally correct and would not produce negative training effects. Therefore, it was considered appropriate to proceed with the evaluation study.

Participants

A class of 21 pilot students entering the air refueling phase of F-4 training with the 311th TFTS participated in this study. There were 11 pilots selected for the Experimental Group and 10 pilots for the Control Group. The two groups were matched as evenly as possible based on performance ratings by squadron IPs and the students progress to date.

Instructors

All instruction on the Director Lights Trainer was given by one IP from the 4444th Operations Squadron. Instruction in the aircraft was given by the regular IPs from the 311th TFTS.

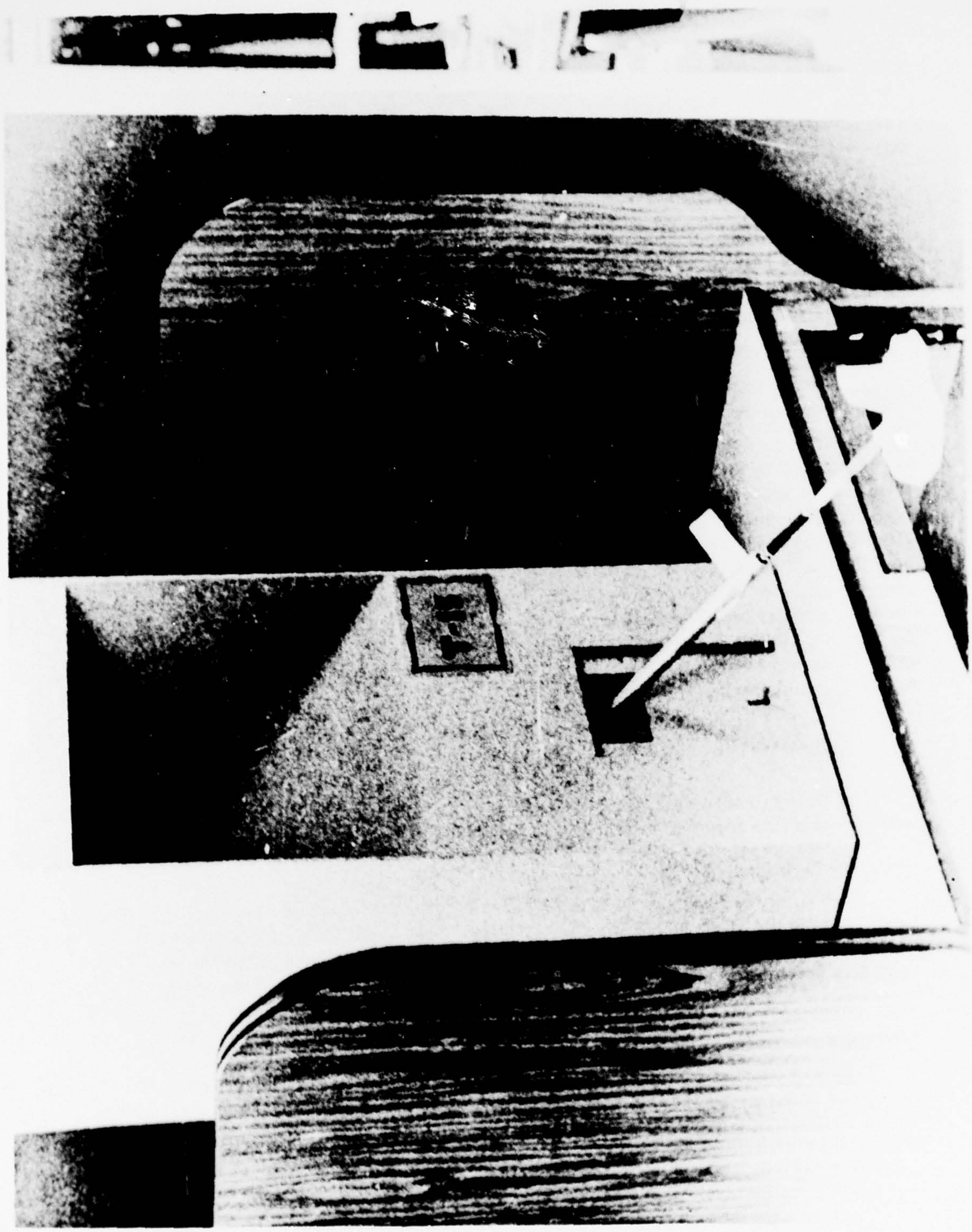

Figure 2. **Director lights trainer, Castle AFB, CA.**

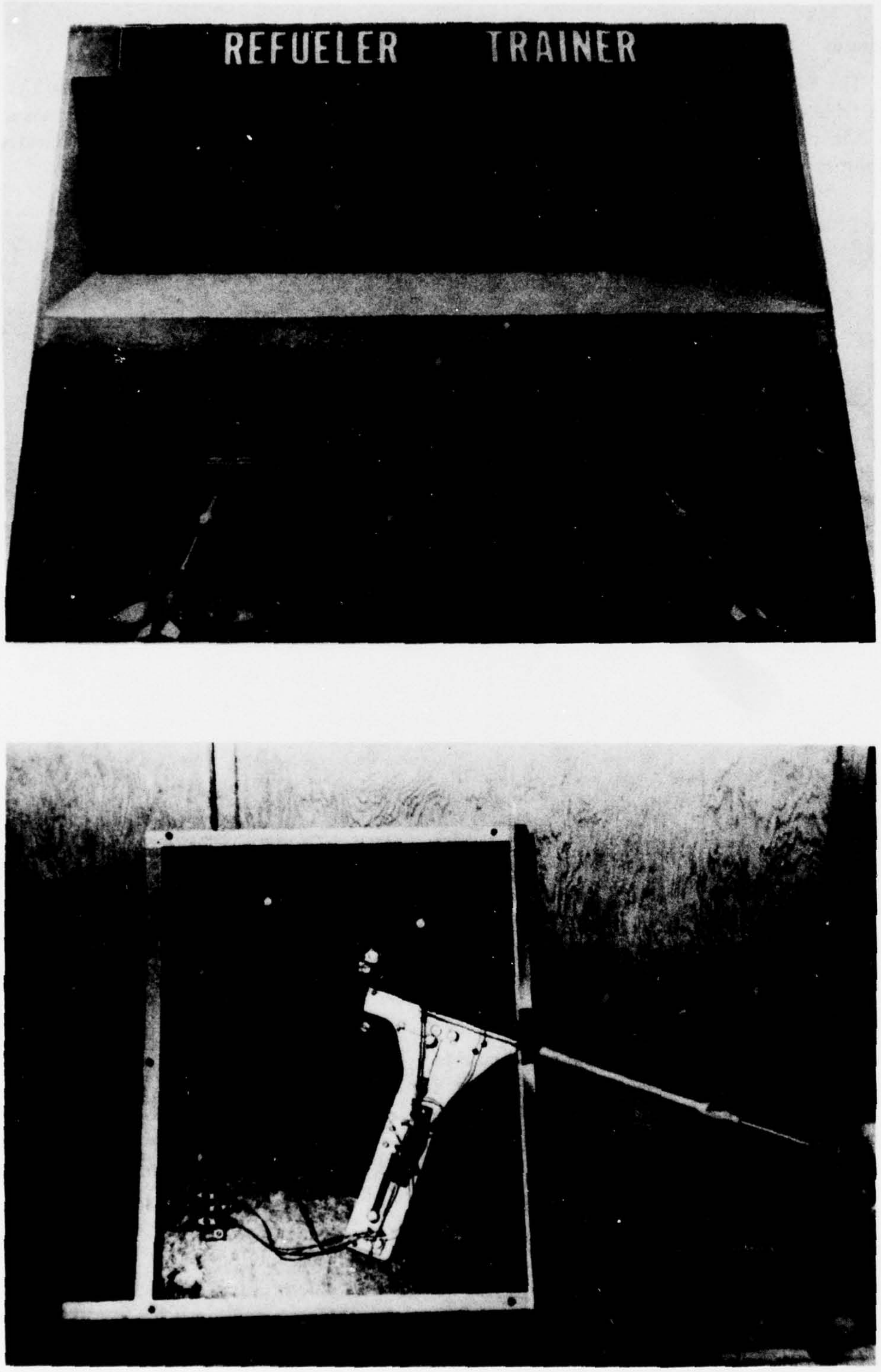

Figure 3. **Refueler trainer, Phase I Model.**

Apparatus

The F-4C aircraft and the Air Refueling Director Lights Trainer were used in this study. The trainer was a tabletop model and was located in the 58th Tactical Training Squadron Learning Center where it was placed in one of the learning carrels. The following description of the trainer briefly delineates those capabilities used in this experiment (see Figure 4).

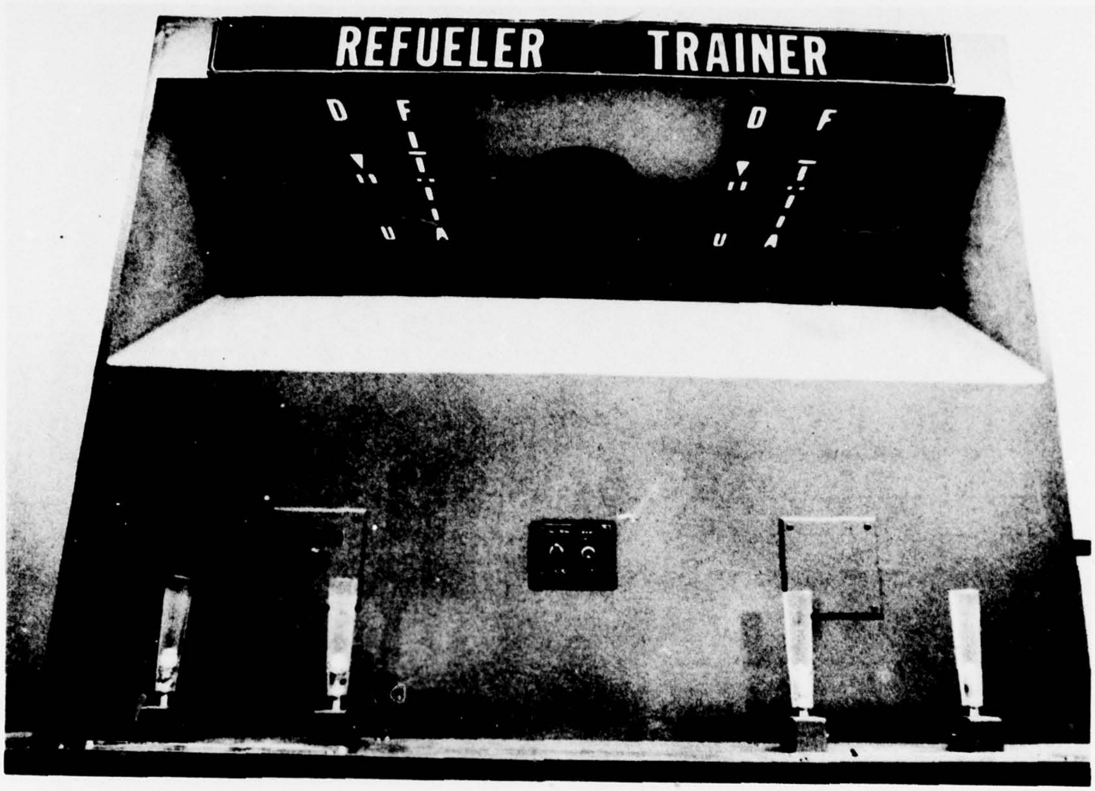

Figure 4. **Air refueling director lights trainer, Phase II Model.**

Stick and throttle controls were mounted side by side at the front of the trainer for both the IP and the student positions (see Figure 5). The director lights were mounted overhead at both positions, at a 90-degree angle to the back of the trainer and parallel to the base of the controls (see Figure 6). The working level on which the controls were mounted was 800 millimeters from the floor. Two straight backed chairs, which had a seat height of 425 millimeters, were used for this study but were not standard equipment for the trainer. The lights replicated those found on the KC-135 tanker (see Figure 1).

On the front panel of the trainer, a breakaway button permitted the IP to flash all of the lights to indicate "Breakaway." Also, two switches were on the front panel, one for normal mode and one for test mode (see Figure 7). The normal mode allowed the IP to make control inputs which moved both sets of director lights. The student could then make control inputs which corrected the lights to a neutral position. When an IP used test mode, he changed the second switch from NORM to AUTO. This introduced automatic cycling into the lights. A rheostat in the back of the trainer could be used to adjust the rate from slow to fast; slow being 40 seconds for a complete cycle and fast being 10 seconds for a complete cycle (outer limit light to outer limit light). The rate used in this study was 10 seconds per cycle (see Figure 8).

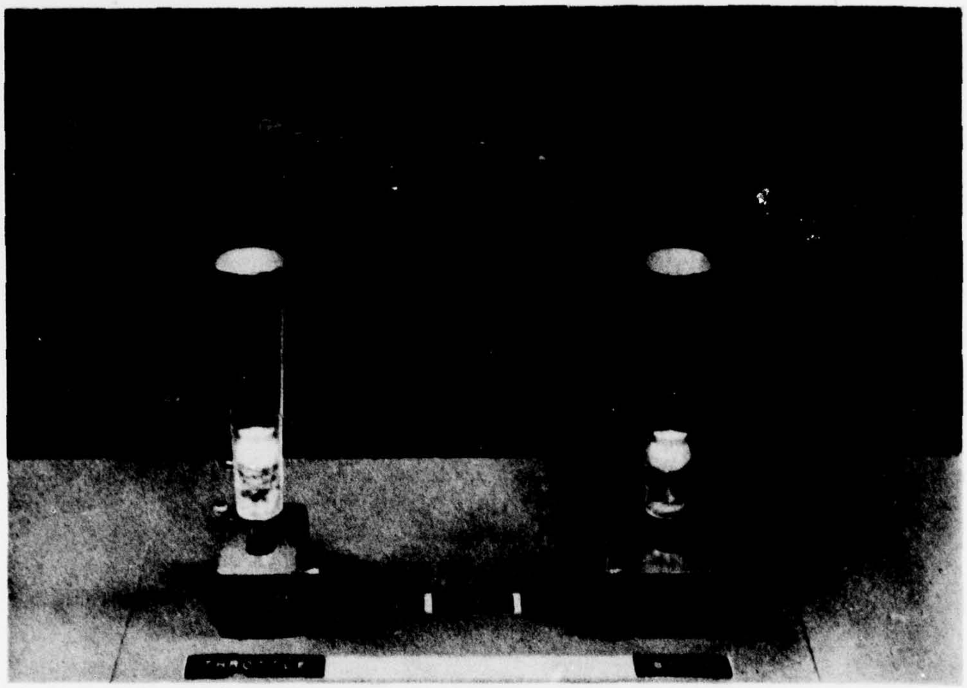

Figure 5. **Controls.**

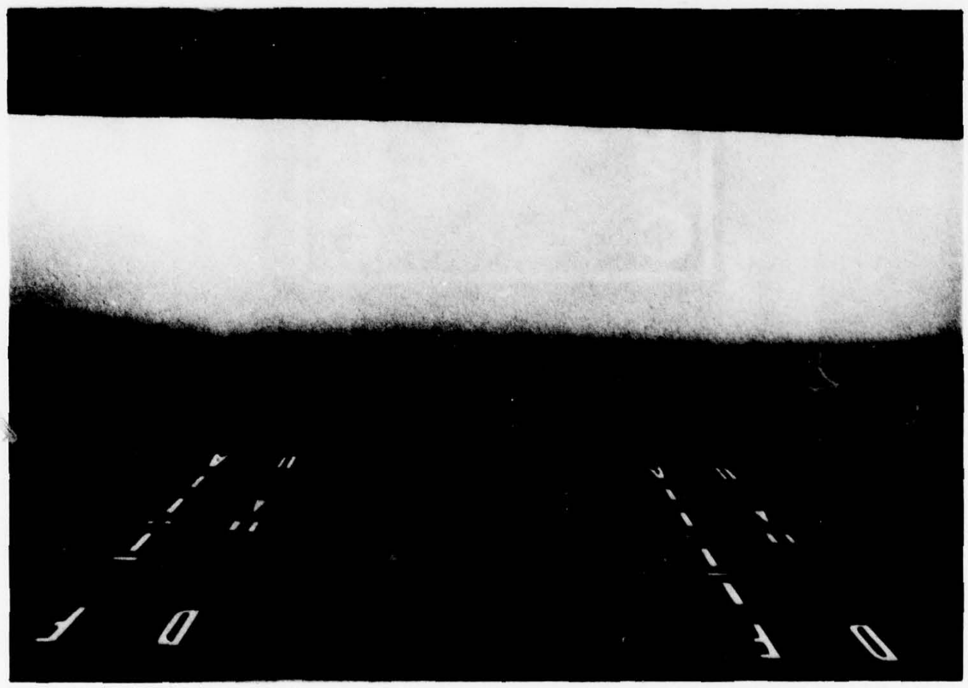

Figure 6. **Director lights.**

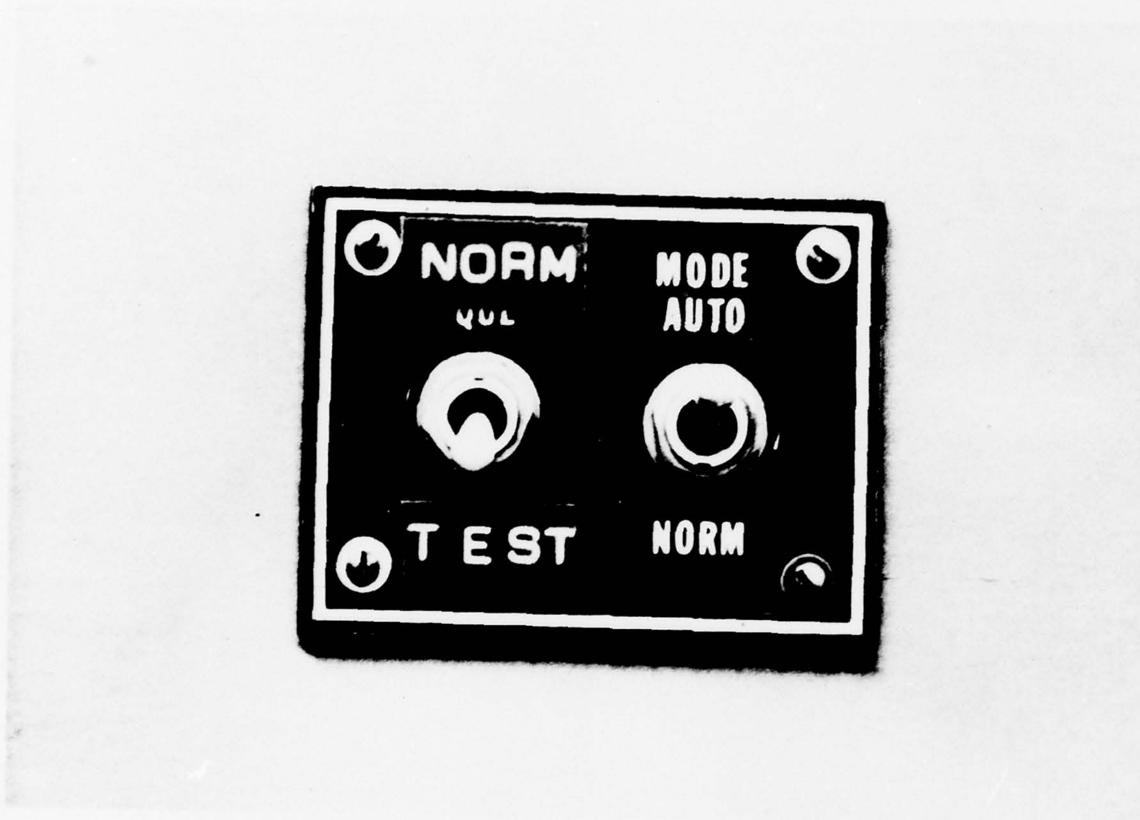

Figure 7. Mode switches.

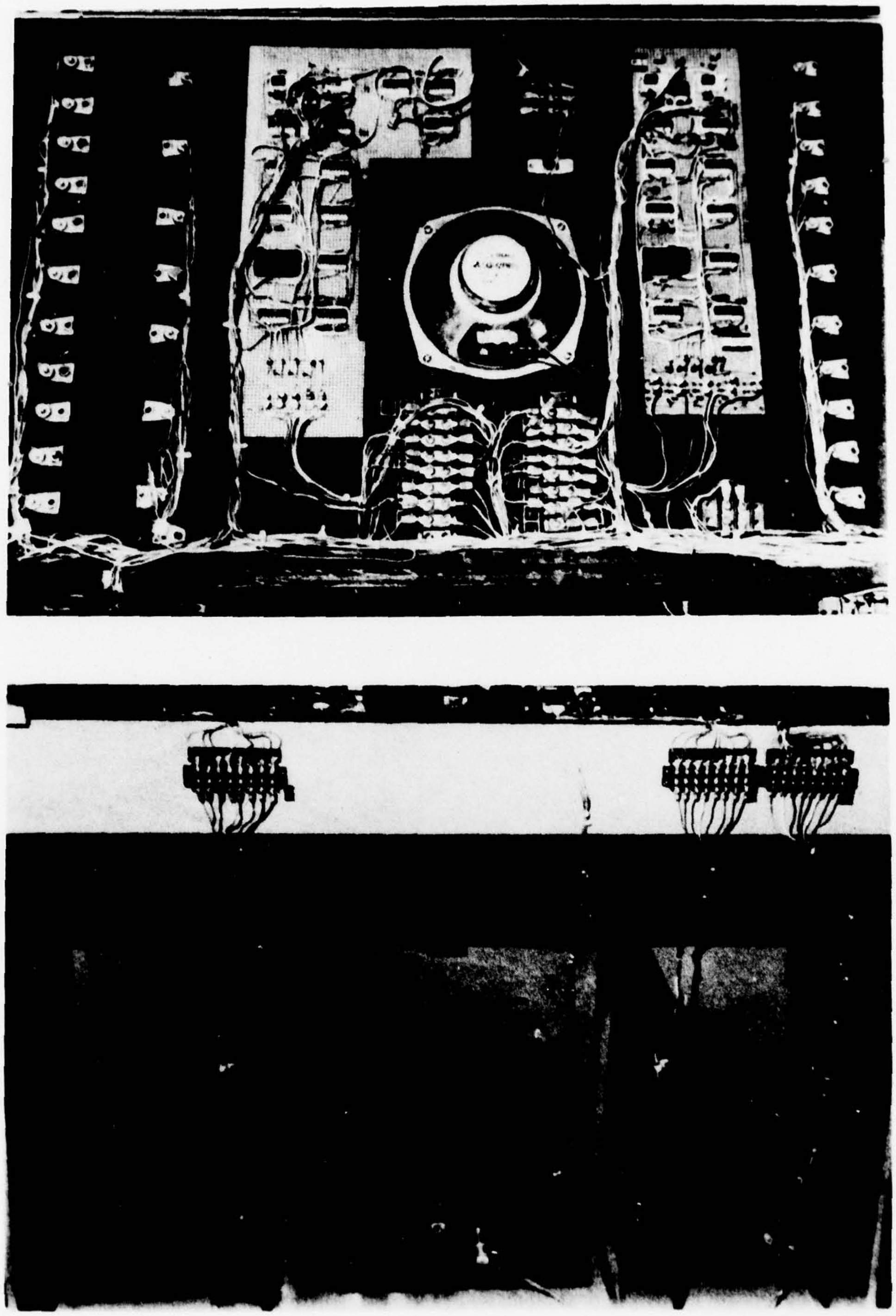

Figure 8. **Internal components.**

A panel on the IP side of the trainer had four switches (see Figure 9). One was for power (white lights on), another was for contact made (green Captains Bars on) and the third and fourth switches to control the fore-and-aft lights and the up-and-down lights (red outer limit lights on) to simulate manual boom operator signalling from pre-contact to contact position.

Figure 9. **Side panel.**

Design

A major objective of the approach was that the study be performed within the context of typical Air Force training operations. This requirement was the determining factor in the study methodology. In evaluating the effectiveness of any training device, the most important experimental design consideration is that of transfer of training (Eddowes, 1977). The dependent variable used in this study was performance in the aircraft during air refueling, and the only independent variable was director lights training. To make full use of the training effectiveness of a device, it must be compatible within the context of its total training program (Caro, 1977). The normal syllabus was varied slightly for the experimental group to allow a 1-hour block of training on the Air Refueling Director Lights Trainer. A 20-minute briefing was given each student in the Experimental Group on the CROs for this block of instruction, the boom limits, and the function and purpose of the director lights. The next 20-minute block of instruction was for orientation and practice on the trainer. The last 20-minute block of time was divided into 5-minute timed trials. The pilots were tested to see whether they could meet the CROs, and those that could not were given another trial. After the training period for the Experimental Group, both groups flew six air refueling missions in the aircraft (F-4C): four were day missions and two were night (see Appendix C).

Performance Measurement

Within the context of this study, performance measures were employed not only to assess student progress but also to evaluate the effectiveness of the device. The essential consideration was whether the device aided the pilots in making correct control inputs as required by the director lights. For any performance measurement system to be useful, it must be both diagnostic and prescriptive. The measures available at present do not necessarily possess these characteristics. Furthermore, many measures that describe the student behaviors do so in a rather general manner.

The system developed for this study had some specific characteristics that were both descriptive and prescriptive. The system (1) Measured pilot behaviors (control inputs), (2) Was three-dimensional, accounting for not only magnitude and direction, but also timing, (3) Described these behaviors in a binary system (correct-incorrect), and (4) Was easy to use and understand by both IP and student.

During the timed trials, grades were recorded by the IP on a special grade slip developed specifically for this study (see Figure 10). The same grading procedures were used by the IPs during each air refueling mission in the aircraft for both the Control and the Experimental Groups. The normal syllabus grades were also recorded for each air refueling mission in the aircraft. Only some of the normal air refueling grades were considered to be adequate measures of the dependent variable; therefore, this study considered only the grades given for mission elements 4 through 8 on the normal grade sheet (see Figure 11).

Instructions: A grade should be recorded for each trial by placing a checkmark (√) in the appropriate blocks. A trial begins at pre-contact position for any attempt at air refueling:

TRIAL NO.	CONTROL INPUTS				REMARKS:
	DIRECTION	MAGNITUDE		TIMING	
CORRECT					
INCORRECT		TOO MUCH	NOT ENOUGH		

Figure 10. **Excerpt of special grade slip.**

INDIVIDUAL TRAINING MISSION GRADE	MISSION NUMBER	POSITION NUMBER	MISSION DURATION	DATE
NAME	AIRCRAFT NUMBER	TMS AIRCRAFT	INSTRUCTOR	

DAY/NIGHT AIR REFUELING MISSION ELEMENTS	UNKNOWN	DANGEROUS	GRADE 0	GRADE 1	GRADE 2	GRADE 3	GRADE 4
1. Mission Preparation							
2. Rendezvous							
3. Observation Position							
4. Precontact							
5. Rate of Closure							
6. Hook-up							
7. Maintain Contact							
8. Disconnect							
9. Radio Procedures							
10. Radio Procedures							
OVERALL GRADE							

GRADING CRITERIA

UNKNOWN -- Performance not observed or the element was not performed.

DANGEROUS -- Performance was unsafe.

0 -- Performance indicated a lack of ability or knowledge

1 -- Performance is safe but indicates limited proficiency. Makes errors of commission or omission.

2 -- Performance is essentially correct. Recognizes and corrects errors.

3 -- Performance is correct, efficient, skillful, and without hesitation.

4 -- Performance reflects an unusually high degree of ability

STUDENTS INITIALS	SIGNATURE OF INSTRUCTOR

Figure 11. **Excerpt of normal grade slip.**

Questionnaire Data

The Experimental Group was queried about the training objectives and hardware configuration of the trainer after the 1-hour block of instruction and again after all air refueling missions were flown in the aircraft. The Control Group was asked the same questions after they received instruction on the trainer, which was given following all aircraft missions. All pilot students were asked questions about their use of the lights and their air refueling techniques (e.g., changing seat position and looking over or under canopy bow) after mission No. 4 (last day air refueling) and mission No. 6 (last night air refueling). For each mission the IPs completed a questionnaire concerning the amount of commentary they gave the students. They were also queried about the difficulty students had with stick and throttle corrections.

Analysis

Using the Univac Stat-Pack (1973), a chi square test for independence was performed on all grades previous to air refueling for each pilot student, to verify that the groups were equally matched before starting the air refueling phase of training. In determining the effectiveness of transfer of training, the usual hypothesis is that the experimentally trained group should exhibit a higher "initial" skill level when the aircraft phase of training is begun (Pohlmann & Reed, 1978). This is a particularly reasonable assumption when the experimental training is "blocked" prior to aircraft training rather than interspersed with the aircraft training. The chi square test was employed to test for this effect. The data collected from the special grade sheets for each air refueling mission as well as the data from the normal grade slips were analyzed as to the number of correct and incorrect control input responses made by each student. Another analysis using chi square was performed to determine whether learning occurred in the aircraft. The student grades on all six rides in the air refueling (AR) phase were analyzed.

III. RESULTS

Group Equality

The groups were verified as being equal before the AR phase began. The frequency distributions of all previous scores are reflected in Table 1. Using a chi square test, this study could find no significant difference between the scores recorded for the two groups of students prior to the training on the Director Lights Trainer. Thus, it was assumed that the groups were properly matched.

Table 1. **Frequency Distribution**

Experimental Group		Control Group	
Grade	Frequency	Grade	Frequency
Grades Prior to AR Phase			
0	1	0	5
1	95	1	94
2	179	2	169
3	9	3	4
4	0	4	0
Scores Prior to AR Phase			
Experimental Group		Control Group	
Grade	Score	Grade	Score
0	0	0	0
1	95	1	94
2	358	2	338
3	27	3	12
4	0	4	0

Questionnaire Data

The open-ended questionnaires were naturally not amenable to quantitative analysis but did provide valuable insights into attitudes and opinions about the Director Lights Trainer. Both the Experimental and Control Groups responded that the Director Lights Trainer did assist them in understanding the function of the lights and making the correct control inputs (81%). The Experimental Group responded unanimously that no negative training had to be overcome in the aircraft as a result of the trainer. According to the IP questionnaires, the Control Group needed more IP commentary to make and maintain contact with the tanker and also had more difficulty with stick and throttle corrections than did the Experimental Group.

Aircraft Data

On AR-1 (air refueling mission No. 1), the Control Group made more control input errors than did the Experimental Group (see Table 2). The Control Group made more incorrect responses than they made correct responses. The Experimental Group made twice as many correct responses as incorrect responses. Using a chi square test, these results were significant at the .06 level on the first ride in the aircraft using the special grade sheets. Using the regular grades given to the pilot students under the normal syllabus, the Experimental Group performed significantly better than did the Control Group for AR-1 ($p < .01$). This seems to indicate that the Air Refueling Director Lights Trainer did, in fact, contribute to the performance of the Experimental Group in the aircraft. Table 3 depicts the frequency distribution of the normal grades given to the pilots throughout the Air Refueling Phase.

To test for learning during air refueling missions in the aircraft, the chi square test was again utilized. The results of these analyses showed that the Experimental Group had an increase in grades between AR-1 and AR-6 which was significant at the .03 level. The Control Group showed an increase in grades between AR-1 and AR-6 which was significant at the .01 level. This increase in grade level can be assumed to have occurred because of learning in the aircraft.

Table 2. **Control Input Responses During Air Refueling**

	Experimental Group				Control Group			
Mission	Correct	%	Incorrect	%	Correct	%	Incorrect	%
AR-1	23	70	10	30	14	47	16	53
AR-2	22	73	8	21	26	79	7	27
AR-3	28	85	5	15	24	80	6	20
AR-4	29	88	4	12	25	83	5	17
AR-5	29	88	4	12	27	90	3	10
AR-6	30	91	3	9	27	90	3	10

Table 3. **Frequency Distribution of Normal Syllabus Grades**

Items 4–8 (See Figure 11)

Mission	Experimental Group Score	Experimental Group Frequency	Control Group Score	Control Group Frequency
AR-1	0	2	0	6
	1	12	1	26
	2	41	2	33
	3	5	3	0
	4	0	4	0
AR-2	0	0	0	0
	1	5	1	8
	2	33	2	34
	3	23	3	21
	4	0	4	0
AR-3	0	0	0	2
	1	2	1	3
	2	30	2	29
	3	23	3	21
	4	0	4	0
AR-4	0	0	0	0
	1	5	1	2
	2	21	2	38
	3	25	3	10
	4	4	4	0
AR-5	0	0	0	0
	1	2	1	5
	2	26	2	25
	3	27	3	20
	4	0	4	0
AR-6	0	1	0	0
	1	2	1	0
	2	29	2	12
	3	28	3	38
	4	0	4	0

IV. DISCUSSION

The research performed in this study addressed the three questions contained in the request for the trainer:

1. Can the training be accomplished with a more economical medium than this device?
2. Is the training equality currently available with other media (i.e., flight simulator)?
3. What functions must this device teach?

The first question concerns economy, and the answer is that the cost of the Air Refueling Director Lights Trainer is minimal. Briefings or a film, such as the one shown to the pilot students during their air refueling phase briefing (see Appendix D), would not provide training in the required psychomotor responses.

To answer the second question requires that all simulators now in the inventory be assessed. Tactical Air Command does not, at present, have a fighter simulator programmed with visual detail to train in this

area, specifically with reference to the director lights. However, the E-3A simulator at Tinker AFB (Tactical Air Command) does have this capability, and the Strategic Air Command is scheduled to receive a B-52 air refueling part-task trainer in late 1978 at Castle AFB (SAC Plan A/F37A-T77). A study was also conducted at AFHRL/FT (Air Force Systems Command) during February 1978 using the Advanced Simulator for Pilot Training to evaluate the visual requirements for training air refueling in future devices (Woodruff, Longridge, Irish, & Jeffries, 1979).

The third question initiated the analysis of this trainer. The device, as it was configured for the study at Luke AFB, was not designed to teach pilot students to air refuel. Its only purpose was to train recognition and response to the stimulus of the director lights with transfer of training to the aircraft. Whether it accomplished this goal was a question this study attempted to answer. Based on the results of this study, training on the Air Refueling Director Lights Trainer can be accomplished in the 1-hour block of time allocated. The number of trials made by each student on the trainer appears at Table 4. It must be restated that the Control Group received this training after all air refueling missions in the aircraft were flown and the data for the study had been collected.

Table 4. **Number of Trials in Director Lights Trainer**

	Experimental Group			
Trials	1	2	3	4
Number of Students	7	3	0	1

64% of the students accomplished training (met CRO) in one trial. 91% accomplished training in two trials.

	Control Group			
Trials	1	2	3	4
Number of Students	2	7	1	0

Only 20% of the students accomplished training in one trial. 90% accomplished training in two trials.

Some recommendations for the trainer were suggested by the pilot students and dealt with the position and feel of the stick and throttle. They indicated the throttle should be moved, perhaps lower or on the side since the controls were quite close together. They also suggested that the centering spring be removed from the throttle since the throttle in the aircraft does not return to neutral. Several students also indicated that the feel of the controls was different from those in the aircraft.

The "automatic" feature of the trainer continued to complete a cycle after it was interrupted by a throttle or stick input by the IP. This resulted in an unsatisfactory training situation because students become aware very quickly that they could anticipate the appropriate response. Several times, the IP requested the students to allow the lights to go out of phase so that the students were then making control responses in different directions.

The trainer was built 1075 millimeters wide, but the seating position and controls location caused both the IP and the student to need a 575-millimeter wide space each in which to work. The trainer should be reconfigured to allow at least a 1500-millimeter working area if the student and IP are to be seated side by side.

The original nomenclature of the device was Refueler Trainer, and the IP who instructed on the trainer had to explain to each student that it was not designed to teach air refueling. A recommendation of this study is that the name be changed to Air Refueling Director Lights Trainer.

The pilots in both groups were queried as to whether a sound-slide presentation would be beneficial as an adjunct to the Director Lights Trainer, and 80% responded affirmatively.

Another recommendation deals with the director lights on the tanker itself. The configuration of the lights on the KC-135 tanker is different from that of the KC-97; however, neither system allows for any flexibility as to type of receiver. One of the considerations brought out in this study was the cross-reference required for eye-hand coordination in fighter-type aircraft. Also, the location of the lights on the tanker fuselage was not consistent with field-of-view considerations for some receivers. With the advent of future tanker and receiver aircraft, designers should take a closer look at the compatibility of these systems. Suggested alternatives to the current configuration might be (a) a flexible "computer scoreboard" type of system that would be adaptable to the specific receiver requirements, (b) relocation of the lights, or (c) multiple locations for various receivers.

V. PERSPECTIVE

The study was performed to meet three objectives dealing with the role and effects of simulation when applied to training the acquisition of air refueling director lights response skills in an initial air refueling training environment. Further, the study was conducted in a manner that was realistic from an operational viewpoint.

In evaluating the usefulness of any device, it cannot be separated from the training program. The cognitive pretraining given in this study, along with the perceptual-motor skills practiced, served to establish a perceptual framework prior to entering the aircraft for the first air refueling mission. This training may have produced a schema or expectation condition within the pilots that allowed for discrimination of the incoming data, thus reducing the information processing load for any given task (Crosby, 1977). Although the effects of this training were not evident on the second aircraft sortie with current measures, this schema may actually contribute to a "wholistic" understanding (Klein, 1977), allowing more attention to the total requirements of air refueling.

Thus, training programs and media, such as this device, may have value not merely in terms of training procedural tasks, but in having a general effect on the overall proficiency for the more complex flying skills.

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APPENDIX A: AIR REFUELING, Excerpt from F-4 Phase Manual F4000B/C/X/I

Local Special Instructions

1. Aircrew members will be familiar with TO 1-1C-1-8 and TACR 55-4 (Chaps 3 and 8).

2. Minimum in-flight visibility for tanker rendezvous with student crews is two miles (Phase manual).

3. When using the alternate anchor refueling procedures (i.e., no CRC or GCI radar available to control refueling operations), additional receiver flights will not depart the ARIP until the previous receiver flight has departed the anchor pattern and the tanker is back in orbit at the anchor point (TO 1-1C-1-8).

4. The precontact checklist will be completed in the observation position or prior to reaching 1 NM in trail (TO 1-1C-1-8).

5. Pressure refueling is prohibited unless required to safely recover the aircraft (Chap 8).

6. See the GA, GAT, or GAN Local Special Instructions for applicable information on post-refueling training.

7. Air refueling will not be attempted by students if the tanker director lights are inoperative. Tanker director lights are the primary reference during refueling operations.

8. In the F4000B course, pilots will fly with the same IP on AR 1-2 insofar as scheduling flexibility will permit.

Supersedes 20 Sep 76
OPR: DOTA

APPENDIX B: CRITERION REFERENCED OBJECTIVES

1. From memory, list the azimuth, elevation, and extension limits of the KC-135 air refueling boom/probe IAW the Air Refueling Phase Manual.

2. Using a diagram of the KC-135 air refueling director lights, describe each light's operation and function during air refueling IAW the Air Refueling Phase Manual.

3. From memory, list six methods of disconnect from the KC-135 air refueling boom IAW the Air Refueling Phase Manual.

4. Using the Air Refueling Director Lights Trainer in the automatic mode, remain within the boom envelope (less than three seconds with any red outer limit light displayed) for a period of five minutes.

APPENDIX C: AIR REFUELING, Excerpt from TAC Syllabus Course No. F4000B

Special Instructions

1. Air Refueling 1-4 will be flown in conjunction with any mission after the BFM phase.

   a. The more restrictive crew line-up shown for each mission will apply.

   b. AR 1-3 must be accomplished prior to flying AR 5-6.

   c. The air refueling training continuity must be closely monitored by supervisors.

   d. A separate air refueling and the respective mission grade slip will be accomplished.

2. TR-13 must be flown prior to GAN-1 and AR-5.

3. GAN special instructions apply to AR 5/6.

4. Air refueling will not be conducted with both the receiver pilot and boom operator in student status. The flight leader will coordinate with the tanker crew to assure compliance prior to any aircraft assuming the pre-contact position.

5. Including GAN 1, a minimum of two night weapons delivery sorties are required. One additional GAN sortie must be flown if circumstances prevent weapons delivery on both AR 5 and 6.

AR-1 Aircraft: 4 Time: 1.0

-2 Crew: IP/WSO; P/IP; P/IP; P/IP

Tanker rendezvous, hook-up, refuel, disconnect, observation position and reform. Proceed with applicable mission.

AR-3 Aircraft: 4 Time: 1.0

-4 Crew: IP/WSO; P/WSO; P/IP; P/WSO

Tanker rendezvous, hook-up, refuel, disconnect, observation position and reform. Proceed with applicable mission.

AR-5 Aircraft: 4 Time: 2.4(Night)

Crew: IP/X; P/IP; P/IP; P/IP Config: D-11/11A D-10

Tanker rendezvous, hook-up, refuel, disconnect, observation position, and reform. Separate into two elements and proceed to separate range/range periods. 30-degree and low angle/low drag bomb with flares, 30-degree and low angle/low drag bomb with ground marking devices, flare delivery, instrument recovery.

AR-6 Aircraft: 4 Time: 2.4(Night)

Crew: IP/X; P/WSO; P/IP; P/WSO Config: D-11/11A D-10

Tanker rendezvous, hook-up, refuel, disconnect, observation position, and reform. Separate into two elements and proceed to separate range/range periods. 30-degree and low angle/low drag bomb with flares, 30-degree and low angle/low drag bomb with ground marking devices, flare delivery, instrument recovery.

APPENDIX D: AIR REFUELING, Excerpt from TAC Briefing Guide Course No. F4000B

Special Instructions

1. Three rules basic to all emergency/abnormal conditions should be thoroughly understood and applied by the pilot:

   a. Maintain aircraft control

   b. Analyze the situation and take the proper action

   c. Land as the emergency dictates

2. Aircrews must be fully aware of the requirements for sufficient crew rest as defined in AFR 60-1, and the consequences when crew rest requirements are violated.

3. In accordance with SACR 55-52/TACR 55-7, air refueling will not be conducted with both the receiver pilot and boom operator in student status. The flight leader will coordinate with the tanker crew to assure compliance prior to any aircraft assuming the precontact position.

4. Each sortie requires a minimum of one wet hook-up and as many dry hook-ups as tanker time allows.

Specific Mission Briefing Guide (AR)

1. SPECIAL INSTRUCTIONS/RESTRICTIONS (Briefing Guide and Syllabus)

2. AIR REFUELING DATA (CARD)

3. REFUELING TRACK

   a. ARIP

   b. ARCP

   c. Altitude

   d. Airspeed

   e. Call sign (tanker/GCI)

4. RENDEZVOUS PROCEDURES

   a. VFR/IFR

   b. Radar join-up

   c. Navigation/receptacle lights

   d. Radio calls

   e. Formation

   f. Hot armament checks

   g. Join-up, observation position

h. Refueling checklist

i. Rendezvous overrun

5. REFUELING

a. Precontact

b. Radio calls

c. Aircraft lighting (receiver/tanker)

d. Techniques (afterburner)

e. Boom limits

(1) 25 degrees – 40 degrees down

(2) 10 degrees left or right

(3) 6–18′ extension

f. Planned offload (log in AFTO 781)

g. Disconnect (primary/secondary)

h. Wake turbulence considerations.

6. EMERGENCY PROCEDURES

a. Refuel valve malfunctions

b. Damaged receptacle

c. Reverse transfer

d. Breakaway

e. Tension disconnect

f. Radio silence procedures (visual signals)

g. Abort point/base

7. OFF-TANKER REJOIN

Refer to Special Instructions and Specific Mission Briefing Guides for post-tanker training